Teacher Packet

John Day Fossil Beds National Monument

Ash Fall Discovery (grades 3-8)
Museum Detectives (grades 3-8)
Blast from the Past (grades 1-3)
Horse Family Tree (grades 9-undergraduate)
Scavenger Hunt – Island in Time Trail

John Day Fossil Beds National Monument, Education Program
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www.nps.gov/joda

Thank you for arranging your group's visit to John Day Fossil Beds National Monument. We are glad you are taking the opportunity to use the monument resources to enhance your classroom experience. We have developed our programs to address many of the science curriculum standards for Oregon Department of Education. This packet will help prepare you for your visit, and provide additional post-visit learning opportunities. **Except for the DVD, all the items in the packet are yours to keep.** Please mail the DVD back, or return it when you arrive at the visitor center on the day of your field trip.

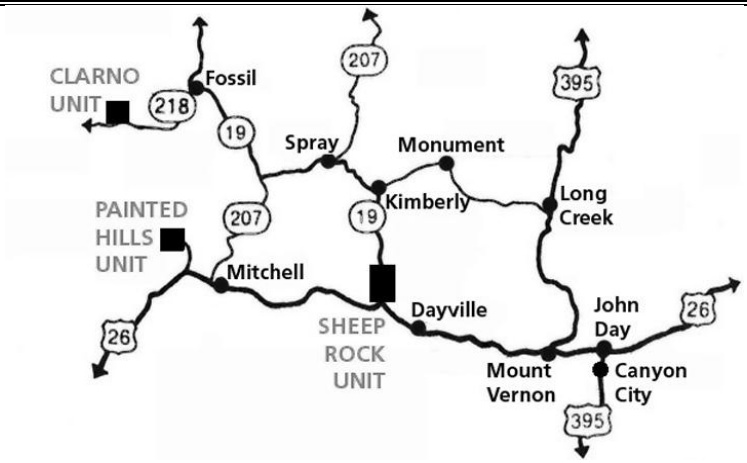
Your students will gain the most from the on-site program if they spend some time preparing for it. There are several hours of pre-visit activities in this packet, such as information on selected topics, classroom exercises and readings.

The purpose of this pre-visit material is to …

(1) give instructors ideas and information for developing classroom, pre-visit programs and activities,
(2) stimulate the students' interest,
(3) build anticipation for the visit,
(4) lay a foundation of knowledge that the National Park Service program leader can build upon, and
(5) provide learning opportunities for the students following their visit.

Please review the contents of this packet carefully. If there is a question or concern about the information please contact the Education Program Coordinator at 541-987-2333, as soon as possible.

TRAVEL DIRECTIONS



John Day Fossil Beds National Monument is comprised of three widely separated units situated in north-central Oregon; the Sheep Rock Unit, Painted Hills Unit, and Clarno Unit. Education programs usually will be conducted at the Thomas Condon Paleontology Center at the Sheep Rock Unit on route 19, located two miles north of the intersection of routes 26 and 19, nine miles west of the town of Dayville.

John Day Fossil Beds National Monument was established in 1975, setting aside 14,000-acres within three widely separated units. At the Sheep Rock Unit visitors can follow trails into the badlands, examine ancient fossils displayed at the Thomas Condon Paleontolgy Center, and explore the Cant Ranch Museum and cultural history exhibits of the region's early human settlement. The Painted Hills Unit, aptly named for its spectacular multi-colored stripes, provides thousands of acres of scenic marvels unique even in the Pacific Northwest and serves as a haven to photographers from around the world. The Clarno Unit's Palisade cliffs tower overhead, preserving a great diversity of fossils from as long as 54 million years ago, when the environment was a semi-tropical rainforest with palms, bananas and avocados!

The greater John Day Basin is one of the few areas on the planet with such numerous and well-preserved ecological specimens, entombed by ash that rained down from the ancient volcanoes of the Cascade Range. Fossil beds that span even 5 million years are rare. Yet the beds of John Day show an almost continuous fossil record of diverse plant and animal life that existed between 54 million and 6 million years ago. John Day Fossil Beds National Monument shares the knowledge of its treasures not only with the general public but also with the greater scientific community. The park's paleontologists continue to uncover new fossils that help tell the story of prehistoric life.

Reservations
Due to a small staff, reservations for educational programs should be made well in advance. There are no charges for any of the programs or entrance fees for the National Monument.

Facilities
Parking is available for vehicles at the Thomas Condon Visitor Center parking lot. We encourage you to plan to arrive about 15 minutes before education programs start, allowing time for a restroom break.

The Thomas Condon Paleontology Center is open from 9:00 am to 5:00 pm year-round; seven days a week except for federal holidays November through February. The Thomas Condon Paleontology Center is a world-class museum with colorful murals that take visitors on a journey from lush tropical jungles to hardwood forests, when prehistoric animals roamed the region. Visitors can also observe paleontologists in the lab preparing newly excavated fossils. Exhibits at the Thomas Condon Visitor Center include an 18 minute orientation film titled "John Day Fossil Beds: A Place of Discovery". There is also a bookstore where books, postcards, posters, t-shirts, and hats are available for purchase. Restroom facilities and drinking fountains are available at the Visitor Center.

The Cant Ranch Cultural History Museum is located across highway 19 from the Thomas Condon Visitor Center. The museum can be found on the bottom floor of the 1917 ranch house built by the Cant Family and is open from 9:00 am to 5:00 pm; seven days a week throughout summer months. Sheep Rock Overlook trail, the River Trail and the Barn trail all start from the ranch house yard. Picnic tables, restroom facilities and drinking fountains are available at the Cant Ranch Museum.

All visitors should carry water whenever they plan to hike trails. Picnic tables and vault toilets are located at trail head parking lots, and at the picnic areas at Clarno, Painted Hills and Sheep Rock units. **Please make students aware that there will be no restroom facilities along the trails.**

Student Conduct and Safety
The following regulations should be discussed with your group prior to their arrival at the monument.

- All the natural features and fossils within the John Day Fossil Beds National Monument are protected.
- Collecting is strictly prohibited.
- Since walking or climbing on the fragile ash beds can cause irreversible damage to fossils, all visitors are required to stay on the trail at Blue Basin.
- All litter must be disposed of properly.

Student conduct along trails:

- Remind students that running, pushing or horseplay in general can lead to accidents.
- A first-aid kit should be carried in the event that a student trips or falls and gets a cut or scrape.
- Students should wear sturdy shoes and long pants are encouraged to reduce the severity of a cut or scrape.

Group size should be limited to 30 students at a time on trails. If your group is larger than about 30 students, we suggest that you divide your class into smaller groups, providing each group with its own leader. The smaller the group, the more individual students will gain from the experience. There should be one adult for five students. Leaders and adults must remain with the group at all times.

Weather
The weather at John Day Fossil Beds is unpredictable. Cold, windy or snowy weather is often possible through late May and in the fall by October. Likewise heat can be an issue - with days in late spring, summer and early fall reaching temperatures into the 90’s and 100’s. Please encourage students to dress in layers which can easily be adjusted to changing weather conditions.

WHAT TO BRING

- **name tags** - helpful for rangers conducting education programs
- **pencils** – to use on the Scavenger Hunt Activity
- **lunch** - if you plan to eat at the monument
- **water bottle**
- **dress in layers** to stay warm and dry, long pants (shorts offer no knee protection if a student falls down),
- **sturdy shoes or boots** (no sandals or open toed shoes)
- **a hat**
- **sunscreen**

Cameras, binoculars, or hand lens are optional; but may enhance the experience. All items should be labeled with the person's name, address, and phone number in case anything is lost.

Field Trips – Recommended Itinerary

Because most school groups visiting John Day Fossil Beds National Monument have the same amount of time available, the following sample itinerary may be useful.

9:15 am Arrive at Thomas Condon Visitor Center. Use the restrooms and prepare groups for programs and hikes.

9:30 am Meet out in front of Visitor Center for a short orientation stressing monument geology and safety concerns. Plan to divide larger groups in half. The first group enters the Visitor Center and meets in the theater for program, while the second group re-boards the bus for a short 3 mile drive north to Blue Basin trail head: "Island in Time" hike.

12:00 noon Groups finish up programs and meet at Cant Ranch lawn for picnic lunch! Take time to visit the cultural history museum in the ranch house and tour the turn of the century Sheep Barn.

1:00 pm Groups switch and repeat programs

3:30 pm Leave John Day Fossil Beds National Monument

Resource Protection

Please help us protect this resource so that future generations of students can also enjoy it. Insist that students stay on the trail, do not litter or throw rocks, and take only pictures. You can point out that, with 115,000 visitors per year, it wouldn't take long for the place to look very different if people were allowed to collect things or take home souvenirs from the Monument.

PROGRAM DESCRIPTIONS

Ash Fall Discovery (2.5 to 3 hour program limited to 30 students)

In preparation for their visit, the students will first participate in pre-visit activities in the classroom. These can include the orientation DVD of five movies, discussion handouts and activities, as described in this teacher packet.

Upon arrival at the monument visitor center the group will view a fossil bed locality and discuss geologic features. They will then briefly tour the fossil museum and become familiar with some of the fossils found in the region. The group will be introduced to the techniques of keeping a field journal and review the procedures followed when prospecting for and finding fossils.

The majority of the program will be spent on activities which focus on how fossils move from discovery in the field to the laboratory. Students will hike into a simulated field site; find their location on an aerial photograph and practice measuring coordinates and recording information in a personal field journal. Their search for fossil replicas will introduce students to the challenges of field work, use of paleontological tools and field notes. Students will see how fossils are transported from the field to the laboratory and participate in a hands-on lab simulation activity.

Upon completion of the activities, students will see a paleontological preparation laboratory, and learn about current fossils being cleaned and prepared. The program concludes with students exploring the Gallery of Fossils with a ranger and finding “their fossil replica” on display.

NOTE: Groups larger than 30 should be divided into two smaller groups. While group A participates in the Ash Fall Discovery program, group B will hike the Blue Basin “Island in Time” trail. This hike will take about 2 hours to complete, including travel time to and from the trail head, approximately 3 miles north of the visitor center. The hike is an excellent opportunity to complete the new scavenger hunt that is available. Also, an evaluation form will be given to the teacher (to be returned by mail, later), as we desire critical feedback to help us improve this program.

ASH FALL DISCOVERY PROGRAM:
Theme Statement, Goals, and Objectives

Theme: Scientists collect more than just fossils when they go into the field. Field notes documenting a myriad of pieces of information offer us a glimpse into past ecosystems.

Goals:
Visitors and students …

1. will experience field work and fossil preparation through simulated activities, encouraging individual appreciation of fossil resources.

2. will understand that in scientific collecting, important information collected with fossils is part of their scientific value.

3. will observe that museums protect fossils and the field notes associated with them, and make them accessible to others. Fossils in a public museum belong to no one person; they belong to everyone.

4. will understand that careful, precise removal of rock from fossils in a laboratory is essential for accurate identification and continued preservation of fossils.

5. will begin to appreciate that the John Day Fossil Beds preserves one of the most important records of Cenozoic plants and animals

Objectives:
Visitors and students …

1. will be able to state why field notes are important and describe what information is gathered when a fossil is discovered.

2. will be able to explain the difference between an ASH FALL and an ASH FLOW TUFF and the likelihood of fossils being preserved in each type of geologic event.

3. will be able to state when Mt. Mazama erupted and how far the ash deposit from this eruption traveled.

4. will be able to identify stratigraphic rock layers in Sheep Rock, and understand the particular layer being simulated in the Ash Fall Discovery program.

5. will be able to find north using a compass.

6. will experience measuring coordinates in 10^{th}s of an inch from an aerial photograph to record a precise geographic location.

7. will become familiar with some of the ancient mammals that have been discovered at John Day Fossil Beds National Monument.

Geologic, Paleontologic, and Contemporary Introduction

To John Day Fossil Beds National Monument (Educator's Reference)

Among the valleys and bluffs of the John Day country a spectacular fossil record is preserved in rock layers. Here scientists continue to unearth a record of land plants and animals extending back 54 million years - to days when strange beasts roamed in lush, near-tropical forests.

A visit here can awaken a sense of time's awesome duration and offer a glimpse into ancient habitats made up of prehistoric animals and plants. Visitors can learn about Oregon's geologic development, the fossils preserved in a priceless archive of ancient life and enjoy the high desert scenic beauty.

The park consists of three separate units, located in the basin of the John Day River, within the Blue Mountain province of Oregon. Although rocks of the nearby highlands date from more than 250 million years ago, the geologic record discovered within the monument and along the John Day River and its tributaries begins with sea life of the Cretaceous Period, roughly 100 million years ago. Each geologic epoch thereafter, has been marked by distinctive sediment layers that contain an outstanding fossil record.

Today, the national monument collection has grown to close to 50,000 specimens. Through current field work each year, about 1,000 new specimens are added to the collection. Scientists have identified over 2,200 species of plants and animals from this fossil record.

The Clarno Formation: Tropical to near-tropical forests mantled Clarno's coastal terrain 54 to 37 million years ago. We know of these forests because of a splendid sample of fossil seeds, nuts, fruits, leaves, branches, and roots preserved in the Clarno Nutbeds and nearby Palisades. The Clarno Nutbeds is one of the finest fossil plant localities on the planet, with hundreds of species - many new to science, preserved in the golden-tan cliffs made up of ancient mudflows.

Among the most common mammals are Amynodonts, a large semi-aquatic "marsh rhino". Amynodonts are possibly derived from early tapirs, but may be closely related to rhinos. Also conspicuous, because of their great size and ungainly appearance among mammals, were Brontotheres. The elongate, massive jaws of Brontotheres were adapted for processing browse, such as leaves and shrubbery. In some fossil specimens, the molars are worn completely flat. Impressive too, were the large-jawed scavengers such as Hemipsalodon. This bear-sized carnivore is large and powerfully built, yet unlike any modern carnivore. Another predator of the Clarno Formation is the cat-like predator, Patriofelis. It was a creodont, an extinct group of mammals that had a very different type of tooth arrangement than later carnivores such as such as bears or cats. Although a few of these lineages continue into the early Oligocene -- about 34 million years ago --

they have left no modern descendants. However, some of their contemporaries: the early equids, rhinos, tapirs, and cats have present day descendants.

John Day Formation: The John Day Formation spans an enormous amount of time - more than 20 million years, from 39 to 18 million years ago. Many types of climates have dominated this landscape. The earlier rain forests were replaced by deciduous forests, and then savannahs. Grasses began to dominate the ecosystems, dramatically influencing changes in both the landscape and animals. The greater range of habitats led to a rich diversity in animal types. More than 120 species of mammals have been found in the John Day Formation, including dogs, cats, peccaries, oreodonts, horses, camels, rhinoceroses, and rodents. Numerous fossil plant localities indicate the great biological diversity of the early Miocene epoch. By the close of these times, mammals had attained their maximum diversity, both locally and worldwide. Thereafter the number of species began to decline.

The Mascall Formation: The interval between deposition of the John Day Formation and the Mascall Formation was marked by intermittent flows of basaltic lava that repeatedly flooded and catastrophically buried landscapes and destroyed ecosystems throughout this region. By 15 million years ago these eruptions had ceased in the John Day Country. At about the same time a number of volcanoes to the south, now called the Strawberry Volcanics, were building high volcanic cones similar in structure to major volcanoes of the modern Cascade Range.

These ancient volcanoes provided the ash deposits and erosional outwash materials that became the Mascall Formation. The Mascall Formation is named after a nearby ranch location and the deposits range from 15 to 12 million years old. A moderate climate, sufficient precipitation, and periodic deposits of volcanic ash, combined to produce highly fertile soils. The volcanic soils supported lush grasses and mixed hardwood forests - much like those found today in the eastern United States.

The Mascall savanna and forest environment allowed new types of fleet animals to emerge. These swift, long-legged, hoofed animals resembled their modern relatives: horses, camels, peccaries and deer. Predators such as bears, weasels, dogs, and cats. Some dwelt in the woodlands, while others adapted to the grasslands. At the same time, large mammals such as gomphotheres (early elephants), rhinos and true cats crossed over from Asia.

The Rattlesnake Formation: Tectonic pressures from the south and north folded and buckled the rock beneath and around the base of the Strawberry Volcanics, eventually thrusting the modern Strawberry-Aldrich mountains upward as much as 1.5 miles above the John Day Valley. The valley floor slowly filled with sandy gravel deposits as the mountains rose.

The interface between the Mascall and the Rattlesnake Formations is easily distinguishable to geologists and paleontologists because the sediments in the two sequences are quite different. The most spectacular clue is best seen from the Mascall Overlook south of Picture Gorge, where a 5% angular unconformity between the Formations can be clearly seen: the Mascall beds are tilted at a different -- steeper -- angle than the younger Rattlesnake deposits. Named for a nearby tributary of the John Day River, Rattlesnake Creek; these youngest rocks in the park, 8 to 6 million years old, also happen to be the least durable. The rocks were deposited in a series of fanglomerates -- coarse materials laid down in alluvial fans, with the pieces relatively unworn -- and as volcanic ashes.

Within the Rattlesnake Formation, there is also a large, blocky welded tuff that represents a violent surge of superheated, volcanic ash and gas from far to the south -- a huge ignimbrite cloud. The rimrocks that can be seen from the Mascall Overlook and eastward along the John Day Valley are relics of this event. Originally this tuff averaged more than one hundred feet thick.

The fossils from the Rattlesnake Formation suggest populations of plants and animals that were adjusted to a significantly dryer, cooler climate than that found in older formations. Grazers such as many extinct species of horses, elephants, rhinos, camels, pronghorns and deer flourished in this prairie environment. They were joined by other common animals such as relatives of peccaries, dogs, short-faced bears, giant ground sloths and true cats. The Rattlesnake Formation is of great importance as one of four correlative localities on which the Hemphillian North American Land Mammal Age is based.

Fossil beds that span even 5 million years are rare. Yet in these valleys, the fossil record shows more than 45 million years of the diverse plant and animal life that existed here from 50 million to 5 million years ago. Typically, fossils are tantalizingly incomplete, or represent only a momentary catastrophe. In only a few areas on the planet have processes, events, and geologic chance combined to produce such a generous array of information as is found in the John Day Fossil Beds.

These are very well preserved specimens: the Clarno Nutbeds have yielded material with cellular structure clearly visible. The John Day Formation vertebrates are among the best preserved of their type and occur in large numbers. The Bridge Creek site yielded over 21,000 plant specimens in a single early collection event, and the Mascall Formation has provided billions of small invertebrates. Also remarkable is the great variety of materials: whole communities, not just individuals are preserved - reflecting rich ecosystem diversity.

All these features are arranged in an unusually orderly sequence. The sequences record amazing mammalian adaptive radiation, shifting climates, global cooling, and other nuances of earth's history - only sparsely hinted at in most localities in the world. The fossil beds contain vestiges of the actual soil, rivers, ponds, watering holes, mudslides, ashfalls, floodplains, middens, trackways, prairies, and forests--in short, a record of entire landscapes. The rocks are rich with the evidence of ancient habitats and the dynamic processes that shaped them; they tell of sweeping changes in the John Day Fossil Beds.

Perhaps best of all, scientists are able to use radiometric dating techniques on the tuff layers between the fossil rich clay-stones to determine the time sequence of these fossils. The fossil rich clay-stones are interbeded between non-fossil bearing tuffs--ashes and other volcaniclastics that serve as markers, or indices, allowing correlation with other formations throughout the world. The result: scientists can receive detailed corroboration or falsification of hypotheses about transformation of climates, lineages and ecosystems throughout broad spans of time.

Exploration and study of the John Day Fossil Beds continues today. In many of the beds, the fossils are widely scattered, and their occurrence cannot be predicted. Fossils deteriorate rapidly once erosion exposes them to the elements. Thus the fossil beds are continually canvassed according to cyclic prospecting schedules. Sites that weather rapidly are revisited more frequently.

Prospecting conducted by the monument's staff results in the collection of thousands of specimens each year. Many of the items are mere fragments--a few teeth, for instance - but, each specimen is accompanied by a wealth of field data. Scientists record coordinates from air photos that pinpoint geographic location and the stratigraphic position of each fossil found. Field notes also include descriptions of lithology – the rocks and soils surrounding a fossil, clues to ancient climates and landscapes. This information, as well as that gained as the fossil is stabilized, prepared, and studied, is entered into national museum files.

Such comprehensive collection efforts provide researchers with scientifically significant samples, which open up intriguing avenues for research. Paleontologists can now detect subtle shifts in the composition of the ecosystems through time. Researchers have identified and studied ancient soils preserved in the John Day Basin and, from a distance of millions of years, are able to gauge former climatic conditions in significant detail. Sedimentologists map the orientation of bones in a Clarno quarry, and thereby plot eddies, backwaters, and gravel bars of a river that flowed 37 million years ago. Paleobotanists determine the rate at which plant communities evolved. A biostratigrapher dates the last known occurrence of a fossil primate in North America. Studies such as these, representing many scientific disciplines, combine to give us a richly detailed picture of the past. These, however, are constantly changing as new data come to light!

The John Day Basin was first recognized as an important paleontological site in the 1860's, thanks to the ability of a young frontier minister, Thomas Condon, who recognized the fossil beds as a scientific treasure. At the time, paleontology was still a new science. However, discoveries such as Condon's galvanized scientific interest. By the late-19th century, researchers at Yale, Princeton and the Smithsonian Institution had received hundreds of specimens from the John Day Basin. They were then classified and described in the scientific literature. This early work set the stage for field geologists such as John C. Merriam who, in 1899, began the task of placing the John Day fossils in their geological, chronological, and paleo-ecological context.

The Blue Mountain Eagle (John Day, Oregon newspaper) Dec. 1, 1916 ...

> "The famous fossil beds of the John Day valley will be an objective point of interest to tourists ... These beds are among the most prolific in rare relics of pre-historic days. They have to the store of scientific research added much of value and of interest. In addition to their value to the scientist they are a marvel to the tourist for their picturesque beauty is worth much. With the opening of travel this way steps should be taken to preserve and conserve these resting places of pre-historic life ... It might be well for the government to withhold the lands from entry and establish here a national park ... As time goes on the value of these beds will be recognized." (1916 was the year the NPS was established)

Concern for the protection of these fossil resources continued to build, and found expression in the establishment of a 1.5 acre Thomas Condon - John Day Fossil Beds State Park at the end of January, 1930. Additions continued until it contained slightly more than 2,681 acres by 1956. Painted Hills State Park, containing 13.2 acres, was purchased in 1947. Clarno State Park was established with 100 acres in 1964-5. Today, the areas are protected by the National Park Service as the John Day Fossil Beds National Monument which was established in 1975 and consists of the Sheep Rock Unit, including the former Thomas Condon - John Day Fossil Beds State Park, about 8,535 acres, the Painted Hills Unit with approximately 3,290 acres, and the Clarno Unit with about 2,050 acres.

Paleontology 101: Fascinating Fossil Facts

(Educators Reference)

Fossils are fascinating. To hold a fossil in your hand and realize that it once was part of a living organism, one that existed millions of years ago, is awe-inspiring. Fossils don't represent the same time periods in the earth's history, nor are they formed in the same circumstances. The following information is designed to put the several types of fossils and the geologic times they represent into a framework or perspective.

For a fossil to form there has to be a specific sequence of events. Rapid and complete burial is a must in all types of fossil formation. This ensures that bacteria and fungi will not begin attacking and decaying the organism. A lack of oxygen in the burial environment is also significant because it limits the rate of decay of organic materials.

Most fossils are found in sedimentary rocks. These types of rocks are formed when many layers of silt, volcanic ash or precipitates build up over time. These layers can be deposited on the bottom of lakes or seas, or in layers on land. Because of the unique chain of events that are necessary for fossil formation to occur, very few organisms turn into fossils. The fossils that we find represent only a small fraction of the life that has existed on earth and are only glimpses into the past. We have to use scientific reasoning and imagination to see a more complete picture.

Geologic Time

Geologic time is very difficult to comprehend, especially for children who are used to thinking of time in terms of minutes and hours and to whom summer vacation, which lies only months away, seems an eternity. The time line activities included in this packet can make geologic time units more real to them and put time into a perspective they can understand.

Before the mid 1900's, it was impossible for even scientists to comprehend the vast amounts of time involved in our earth's history. That was because the only method for dating different rock layers was relative dating. This dating method is based on the assumption that rock layers build up in a chronological sequence, with the younger rock layers lying on top of older layers. Thus, fossils found in two different layers of rock could be dated relative to one another, with the older fossils found in the lower layer. However there was no way to tell how old either fossil actually was.

Index fossils are fossils that are indicators of a particular time in the earth's history. Plants and animals that evolved quickly and flourished for a short period of time before becoming extinct are indicator species. If they became fossilized

and occur in a particular rock formation, they are an indication of the relative age of the rock. While these index fossils can be accurately dated with radiometric dating, they are also very useful in relative dating.

In the middle part of this century, a new technique, called radiometric dating was developed. This method is based on the observation that radioactive elements, radioisotopes, break down into other elements at a fixed rate. By measuring the amount of radioactive elements in a rock, figuring out what proportion of radioisotopes have broken down into other elements and using the rate at which this breakdown is known to occur, scientists can estimate the approximate age of a layer of rocks.

When scientists began to discover the vast amounts of time involved in the earth's history, it became necessary for them to develop a means for dividing time into more manageable periods of time. A system was then created that divided stages of time based upon the evolving changes in life on the planet. The chart provided gives a breakdown of time and life forms associated with different eras and epochs and the activity "When in the World" lets students obtain a hands-on sense of geologic time.

The Main Types of Fossil Formation are:

1. Petrification (Permineralization): This type of fossilization occurs when certain parts of an organism are saturated with a mineral-rich solution. The solution (water that has dissolved minerals in it) penetrates into the organism and gradually the minerals begin to fill in the cell walls of the organism. Highly porous materials such as bone and wood are often permineralized. Examples of petrified fossils are the petrified wood found at Petrified Forest National Park and dinosaur bones found at Dinosaur National Monument.

2. Carbonization or Imprint Fossils: In this process the organism becomes buried in layers of sediment. As the layers of sediment build up, the sediment becomes pressurized from the weight, squeezing out water and gasses from the organism. Eventually the organism disintegrates except for the carbon. This carbon leaves an imprint or residue. Examples of carbon or imprint fossils are found at John Day Fossil Beds National Monument, Florissant Fossil Beds National Monument and Fossil Butte National Monument.

3. Molds and Casts: Molds are fossilized replicas of the structure of an organism. The best examples of this type of fossil are clams or brachiopods. When a clam dies; over time the soft parts of the animal decay. The shell is left empty and this becomes filled with sediment. Eventually the shell dissolves away, but the sediments have hardened and remain as a fossil. An external mold shows the outer surface of the shell and an internal mold shows the inside surface.

The difference in casts and molds lies in what happens when the shell dissolves away. If the shell dissolves before its empty cavity is filled, it leaves a void in the surrounding rock, which then becomes filled with sediment. The “cast” fossil that forms in the cavity shows signs of the outer shell features.

4. Trace Fossils: Trace fossils are preserved remains or signs of animals left behind as they went about their lives. They include footprints, or tracks, burrows, nests, eggs, and feces.

How do paleontologists find fossils? The best way to find fossils is to look for them. Paleontologists often spend many days searching the ground for small fragments of fossilized shell or bone that might indicate that something worth digging up lies beneath.

Fossils are not found everywhere, so scientists must use clues to help them narrow their search. The best way to start is by studying a geologic map. A geologic map shows the age and type of rocks at the surface. This method works because paleontologists generally know the age of fossils they want to find and whether they lived in a marine (saltwater) or non-marine (freshwater or dry land) environment.

Studying a geologic map will often allow a paleontologist to narrow the search down to a few square miles. Other factors that are important in deciding where to look are how well the rocks are exposed (looking for fossils is more productive where there is less vegetation covering the ground) and who owns the land. Often, permits are required to enter and dig on land owned by the public as a whole. Only certain types of fossils on public land can be collected without a permit. If the land is privately owned, the fossils are the property of the landowner and he or she must give permission.

When a location has been chosen the next step is to begin prospecting. Prospecting is searching the ground for fossils and deciding whether or not anything important lies underneath. Searching for fossils in most areas is very time consuming and often frustrating when, after many days of searching, nothing of interest turns up. But there is no better feeling of satisfaction than making a new find. When a paleontologist finds a fossil he or she must be careful to plot its position on a map so the place can be found again. The fossil or its wrapping is also labeled and notes made so that it can be associated later with its location.

Collecting a Fossil. In some areas fossils are collected from surface finds only. Elsewhere a surface find may indicate that digging could uncover more fossils. If fossils are small and relatively durable, they may be collected simply by putting them into a box or vial with a little padding. Large fossils, on the other hand, such as those of dinosaurs, may require large-scale excavation and

sophisticated wrapping and reinforcement to keep the fragile specimens from breaking up.

Paleontologists usually try to identify what they have found while still in the field. But dirt and rock covering a fossil may make identification difficult, and too much preparation (cleaning) under field conditions may damage the specimen. Thus, careful preparation and study are usually saved for the laboratory. Because of this, exciting discoveries are often made after specimens have been returned to the museum and prepared.

Recording Critical Information. Collecting fossils usually involves collecting more than the fossils themselves. Fossils are useful only if details about where and how they were collected are also recorded. Field paleontologists take careful notes and record everything they find. They record the kind of rock and the position in the "stack" of sedimentary rocks where the fossils were found.

The science of stratigraphy deals with the stories told by sequences of rocks-older rocks down low, progressively younger rocks stacked on top. So, knowing the stratigraphic position of a fossil is necessary to add the new information to the stratigraphic story.

Knowing the kind of rock that fossils are preserved in helps put together the story of the environment in which the fossilized plant or animal lived and how it came to be a fossil. When the location of each fossil find and any other information the paleontologist thinks important have been recorded, then it is time to go to the museum.

The Prep. Lab. The first step on returning to the museum is to clean the remaining dirt off the fossil, and glue it together if it is broken so it can be handled and stored. This is called preparation. A preparator is a person trained in the techniques of excavating, cleaning, and strengthening fossils. A preparator also needs to have training in the anatomy of the creatures he or she is preparing, so that important details will not be overlooked or destroyed.

After the fossil is clean and stabilized it can be studied, displayed, or stored for future use. Preparators quite often paint a permanent number on fossils (like a library catalog number on a book) so they can be found later. A collections manager is the person responsible for storing and keeping track of all the fossils in a museum collection.

There are several ways that a fossil can be useful once it is in a museum. Most fossils are part of research collections. Paleontologists use research collections to study the anatomy of the plants and animals they are interested in, and to discover paleo-ecological different ancient organisms. A museum scientist, called a curator, specializes in the types of plants or animals in a collection. Curators often write books or shorter articles about their research interests. They

often use the research collections of many museums to do their work. Displays of fossils allow the museum curator's scientific findings to be made available to a wider audience than if they were only described in print. Displays allow fossils and other natural objects to serve an educational purpose for schools and the general public. This is important because museums depend on the general public, either directly, through museum memberships and contributions, or indirectly, through government grants, for the funding that allows them to do their work. Also, paleontologists are justifiably proud of their finds and are eager to share them with as many people as possible.

Conservation of paleontological resources. What is a paleontological resource? Fossils can be thought of as a kind of natural resource, something that occurs in nature that is useful for society. Fossils are non-renewable natural scientific and educational resources. The economic benefit of fossils may be less obvious than that of, say, coal or oil, but they are resources nonetheless. Closely associated with paleontological resources are other important pieces of information. The rocks that fossils are found in are valuable for paleontologists because they can tell about where the fossil organism lived and how it died. Stratigraphy (the story of layers in rock) is also important because it allows scientists to put fossils in perspective. So, the lands around places where fossils are found are needed by paleontologists to help them understand the resource.

How Paleontologists conserve paleontological resources. Paleontologists have a code of ethics that guides them in their work and encourages the most efficient use of the resource. They are careful to get permission from the owner of the land on which they intend to work. If the land is owned by a state or federal government, they must apply for a permit to work there. Application for a permit requires describing what the paleontologist wants to look for and why, what kind of digging will be required, and how long the project will take. Paleontologists try to disturb the land only as much as necessary to extract the fossils. They also remember to close gates and not disturb livestock that may be present.

Most paleontologists agree that vertebrate fossils, because of their rarity, should be collected and used primarily for scientific research and teaching. Generally, vertebrate fossils are not collected simply to be sold. Because of the quality of molding and casting today, high-quality plastic casts can take the place of actual fossils when it is necessary to share fossils with other museums, schools, or private individuals. Often the sale of casts can pay for part of the expense of excavating and preparing a large fossil.

How amateurs can conserve paleontological resources. Amateur paleontologists can and do make valuable scientific discoveries. But their discoveries are valuable to science only if they can be made available to people qualified to study them. For that reason amateurs can be most effective if they work through a museum or university. Scientific contributions can be made if

someone recognizes rare and unstudied specimens and brings them to the attention of a specialist.

If done in a professional manner, amateur paleontology can be a successful and rewarding hobby. The greatest rewards will come to amateurs who know that their discoveries are going to help the science of paleontology. The true value of a fossil lies in the story it tells about our past. The specialist puts together the stories of many different fossils and adds to the big picture of life in the past. Sharing this knowledge with other scientists, students and the public can enrich all of our lives.

Pre-Visit Activities & Handouts

Here are several activities and handouts that may help your students better understand the geological processes at work in the world and specifically the geology of the John Day Fossil Beds National Monument. The activities and handout topics are described in detail on following pages.

Part I

Discussion: Your students will be participating in a simulated field site activity. You can help prepare your students for their field trip by discussing with them the idea behind a simulation. Ask why astronauts take simulated flights? Why practice and training are important in any type of job? Introduce the idea of preservation as a means to prepare them for their visit to a national park. Ask them what they should do if they see a fossil out on the trail while visiting the monument, and encourage them to help protect all things found within a national park. For more information on national park rules and regulations you can visit us on the web at www.nps.gov/joda

Discussion: Some discussion about volcanic processes would be helpful. Ask students what kinds of material comes out of volcanoes, i.e. ash, lava, rock, gasses, etc. Discuss the terms: geology, paleontology, and archeology. Introduce the idea of field notes, and the need for accurate recordings of data. The park ranger leading the program will be going over all of these things during the program as well.

Part II

Social Networking with John Day Fossil Beds National Monument

- Receive regular tweets from our paleontologists and park rangers about what's happening now in the fossil beds by following our twitter feed. www.twitter.com/JDFossilBedsNPS

- Receive status updates from our paleontologists directly in your Facebook news feed, with photos, videos, and discussions about the fossil beds. www.facebook.com/johndayfossilbeds

- Subscribe to our YouTube channel to watch podcasts about the fossil beds and learn about paleontology. www.youtube.com/JDFossilBedsNPS

- View and download free public domain images of the monument on flickr. www.flickr.com/photos/johndayfossilbeds

Part III
Web cams at John Day Fossil Beds National Monument: www.nps.gov/joda

- **Sheep Rock Webcam**
  Sheep Rock is one of the magnificent centerpieces of John Day Fossil Beds National Monument. Located just across the John Day River from the Thomas Condon Paleontology Center, it rises over 1,000 feet above the valley floor. Colorful, fossil-rich volcanic ash layers can be seen on its slope. The camera is located at an elevation of approximately 2,100'.

- **Paleontology Lab Webcam**
  Science takes center stage at John Day Fossil Beds National Monument. Our Paleontology Lab Cam, the only one like it in the National Park Service, allows you to watch our paleontologists as they work on real fossil specimens! You may see them using a miniature jackhammer to remove rock from around a fossil, or using clay and plastic to create replicas of our fossils for study and education.

HANDOUT

Vital DVD Viewing

Enclosed with this teacher packet will be a DVD that contains five short videos. The films are shown at the park to orient visitors to the geologic and paleontologic history of the John Day river basin.

Prior to your visit, we encourage students to view “A PLACE OF DISCOVERY” or “IMPRESSIONS OF THE PAST” as well as “OREODONT REMOVAL”.

1. **A PLACE OF DISCOVERY** (18 minutes) 2001, this DVD segment is the primary visitor orientation movie of the John Day Fossil Beds National Monument. Featuring the geologic and paleontologic history of the monument, this informative DVD program includes outstanding footage of fossils, lab prep work and explains the fascinating geologic story of this region. **Ideally suited for grades 4-adult.**

    - **Discuss … “Why is this region “A Place of Discovery”?**
      Answer: [This region contains an almost continuous fossil record of diverse plant and animal life that existed between 54 million and 6 million years ago. With more than 750 identified sites, the park’s paleontologists continue to uncover new fossils that help tell the story of prehistoric life.]

2. **IMPRESSIONS FROM THE PAST** (17 minutes) 1989, This film produced by Dayville High School, tells the geologic and paleontologic history of the monument making use of exceptional scenery shots of the current landscape and the technique of “clay-mation” to create the past environments and animals of the last 50 million years. **Ideally suited for grades 1-4.**

    - **Discuss … “What types of plant environments made up each of the four formations that covered 40 million years of the last 65?”**
      Answer: [1. near-tropical forests 2. hardwood temperate forests 3. woodland to grassland savannahs 4. grasslands]

3. OREODONT REMOVAL (15 minutes) 1998, this film highlights the steps used to remove a fossil oreodont skull once it was found in the field. Narration is by Scott Foss, a collections manager at the John Day Fossil Beds National Monument.

- **Discuss … "What steps are used to remove a fossil from the field?"**
  Answer: [1. Carefully isolate the fossil from the surrounding rock by removing overlaying matrix. 2. Protect the fossil with tissue, a plaster jacket. 3. Remove the fossil and finish encasing in plaster.]

4. OREGON FIELD GUIDE (12 minutes) 1993, this film focuses on the work of the paleontologists at the monument, detailing the type of work they conduct in finding, preserving, and studying fossil resources.

- **Discuss … "What kinds of information do you think the paleontologists gather before they remove the fossil from the rock?"**
  Answer: [exact longitude, latitude, elevation; specific strata entombing fossil, exact position in strata, spacing of fossil pieces, date found and removed, distance from dated strata, photos, who found it, ect…]

5. EQUINE EVOLUTION (5 minutes) The Smithsonian Institute produced this short, but informative film explaining the evolution of the horse, as evidenced by fossil discoveries and the fossil record.

- **Discuss … "What changing parts of the horse body did the film feature?"**
  Answer: [teeth, skull size, feet and toes, eye socket]

Pre-visit Activity Questions

1. **When is it good to collect a fossil?**

2. **Are there times when it would be best not to collect a fossil? When?**

3. **What does a paleontologist do?**

4. **Is Paleontology important to you? Why or Why not?**

5. **Would you like to be a paleontologist? Why or Why not?**

Pre-visit Activity Questions and Answers

1. **When is it good to collect a fossil?** *Children should understand that not even professionals collect fossils unless they are prepared to do so. This includes knowing something about the fossils of the area you are collecting in, and knowing how to collect a fossil without damaging it.*

2. **Are there times when it would be best not to collect a fossil? When?** *Fossils should not be collected without permission of the person or government agency that is responsible for the land. It is also best not to collect fossils if you don't yet have experience.*

1. **What does a paleontologist do?** *A paleontologist studies fossils and puts together stories of life in the past*

2. **Is paleontology important to you? Why or Why not?**

3. **Would you like to be a paleontologist? Why or Why not?**

John Day Fossil Beds
A Place of Discovery

Watch the "John Day Fossil Beds, A Place of Discovery" video and answer the following questions.

1. How have the field techniques from the past changed; how have they stayed the same?

2. Name one type of animal or plant discovered at John Day Fossil Beds that does not live in Oregon today.

3. What are some of the things that make the John Day Fossil Beds so significant?

4. What is one other thing you learned about John Day Fossil Beds National Monument from watching the film?

TEACHER REFERENCE

John Day Fossil Beds,
A Place of Discovery

Watch the "John Day Fossil Beds, A Place of Discovery" video and answer the following questions.

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1. How have the field techniques from the past changed; how have they stayed the same?

   Field techniques have changed in that new advances have been made in the consolidants and glues used to stabilize fossil material in the field. Essentially, the jacketing techniques using burlap and plaster have remained the same.

2. Name one type of animal or plant discovered at John Day Fossil Beds that does not live in Oregon today.

   Rhinos, camels, elephants, crocodiles, sabertooth cats, oreodonts, giraffe-deer, mastodonts

   banana, metasequoia, palms, magnolias, plants from the linden, avocado and tea families.

3. What are some of the things that make the John Day Fossil Beds so significant?

   The significance of the John Day Fossil Beds is that it contains one of the longest and most continuous records of evolutionary change in the world.

Ralph W. Chaney – "No region in the world shows a more complete sequence of Tertiary land populations, both plant and animal than the John Day Basin."

4. What is one other thing you learned about John Day Fossil Beds National Monument from watching the film?

OREODONT REMOVAL

Watch the "OREODONT REMOVAL" video and answer the following questions.

1. What layer does the paleontologist say he is working in?

2. What kinds of notes does the paleontologist record before working on the fossil?

3. What kinds of tools and materials does the paleontologist use in the field?

4. Where in unit F is the paleontologist working?

5. What is one other thing you learned about Paleontology from watching the film?

Teacher Reference

OREODONT REMOVAL

Watch the "OREODONT REMOVAL" video and answer the following questions.

1. What layer does the paleontologist say he is working in?

   Unit F, below the Picture gorge Ignimbrite, in the Turtle Cove Member of the John Day Formation (or group)

2. What kinds of notes does the paleontologist record before working on the fossil?

   - *Field number – initials of the person who found the fossil, the month and the year the fossil was discovered and the number of fossils collected by that person. Example**: JD9-04-5** would be the 5th fossil found by John Doe in September 2004.*
   - *Identification of the fossil – the fossil is identified as the skull of an Oreodont.*
   - *Geographic location – where the fossil would be found if you are looking at a map or aerial photograph.*
   - *Geologic or stratigraphic location – the precise rock layer*

3. What kinds of tools and materials does the paleontologist use in the field?
   - *Pick (also called a "scratch awl")*
   - *Paint brush*
   - *Hammer and chisel*
   - *Plaster bandages*
   - *Water*
   - *Plastic coating called "VINAC" (short for vinyl acetate)*

4. Where in unit F is the paleontologist working?

   The paleontologist in the film was working on Sheep Rock. Sheep Rock is located across the John Day River from the visitor center at the John Day Fossil Beds National Monument. The dark layer in the middle of Sheep Rock is called the Picture Gorge Ignimbrite. Unit F is below the Picture Gorge Ignimbrite.

5. What is one other thing you learned about Paleontology from watching the film?

ACTIVITY

PATTERN EVOLUTION

This 30 minute activity will test a student's ability to recognize orderly and logical changes (growth) in a given pattern. The patterns used in this activity have been fabricated but are similar to the complex patterns of teeth, which have shown great changes over time and are important in the identification of animals. (You may wish to have the students look at their molar teeth in a mirror just to see a tooth pattern) There are two "phases" to this activity. An answer sheet for the teacher is attached.

Directions: Divide students into a few work groups, each group having about 3 to 5 students. Give out a copy of the attached pattern sheet (the one having ten patterns on it) for each group. Have each group take the pattern sheet and cut a circle around each pattern, leaving the identification letter on the cut-out circle with the pattern. Each group should have a flat, table surface to work on, allowing them to move the patterns around. The teacher should keep a copy of the pattern sheet as a reference during discussions.

Phase One: (10 minutes in length) Have the students arrange the ten patterns in a logical order, let's say bottom-to-top on the table surface as the direction of change. The logical order of their pattern arrangement should be based upon the changes they observe in each pattern. Tell them that they should discuss their reasons for placing each pattern in certain positions. No other information is offered at this time.

After the allotted time, let the students take a couple of minutes to walk around and look at the other groups' arrangements. See the answer sheet attached for a response as to which group has the right pattern arrangement.

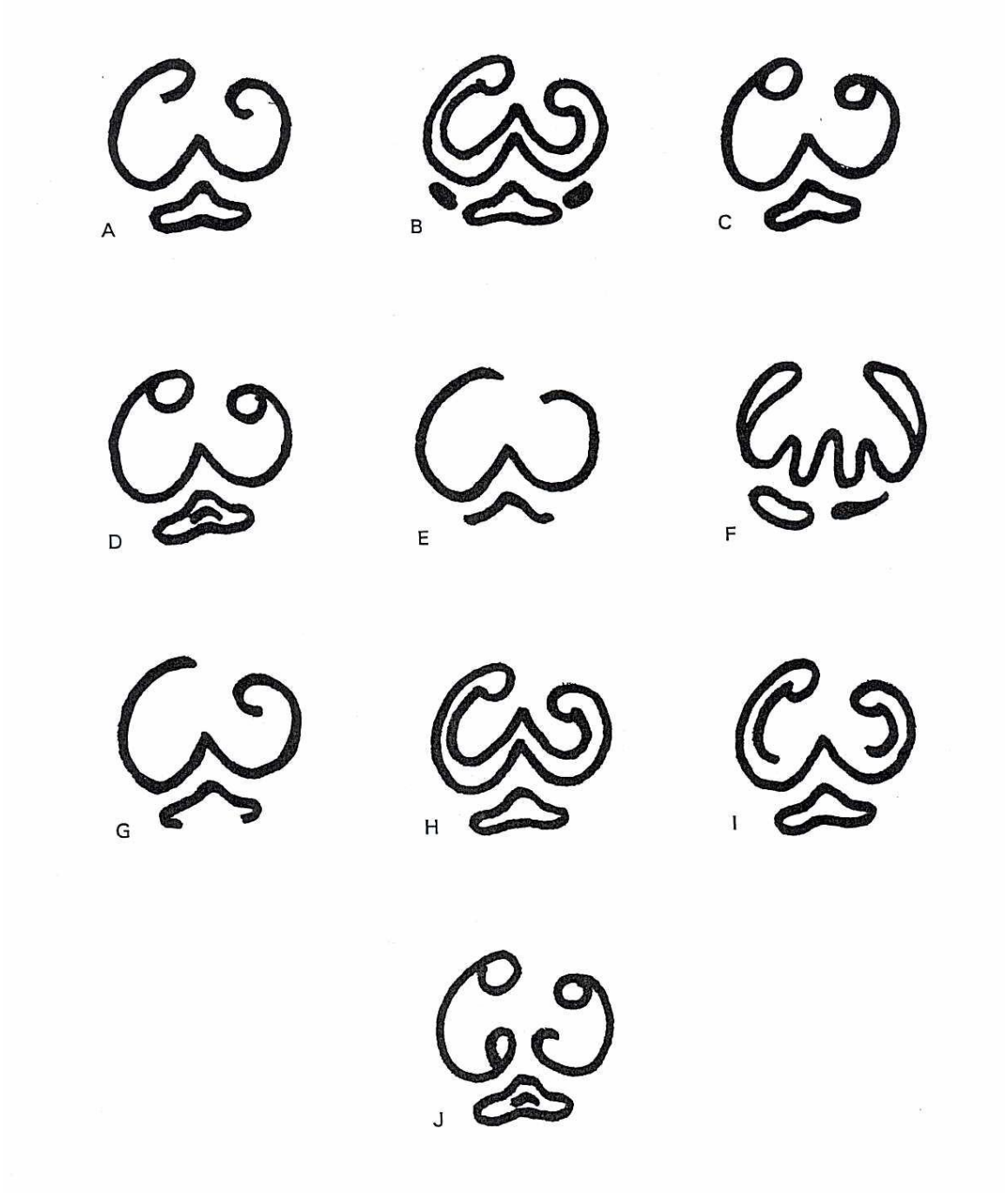
Phase two: (10 minutes in length) Now let them know you are going to give them three bits of information that may help arrange their pattern. These are …

1. The pattern tends to get more complex over time.
2. A pattern or two may not fit into the arrangement.
3. Each pattern has an age, which is:

A = 7 years old	D = 5 years old	H = 5 years old
B = 3 years old	E = 10 years old	I = 6 years old
C = 6 years old	F = 2 years old	J = 8 years old
		G = 9 years old

Now, with this information, let them again discuss and arrange their patterns. After the allotted time let them briefly look at each other's arrangements. Refer to the answer sheet to see which group has the most correct pattern arrangement. Let each group tell the class why they decided on their arrangement.

The Ten Patterns: (cut a circle around each)



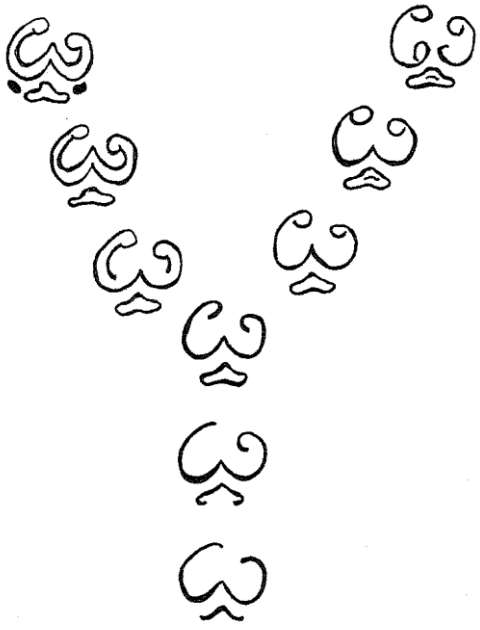
Pattern Evolution Activity Answer Sheet

Phase One: There are no right and wrong answers in Phase One. You will probably see many different pattern arrangements, far different from the most correct arrangement given below. Should one group come up with something close to the "Y" arrangement below, that group has great insight and intuition. At this point in time there is not enough information given to set the parameters as to what the arrangement represents from top-to-bottom on the table-top … complex-to-simple or simple-to-complex? Older-to-younger or the reverse? Can pieces of the pattern disappear and reappear later? Is the arrangement limited to a single line shape? Circular with evolving and de-evolving patterns? etc. etc.

The important thing is the group discussion and dynamics as they arrange the patterns and that the group set up their own parameters to influence how they would arrange the patterns.

Phase Two: Just looking at the students' new patterns one can see how parameter information can effect the arrangement of the patterns. Pattern ages (time), pattern complexity growth, and the possibility of non-functional patterns, give the groups clues to look for in laying out their arrangements.

The leap from thinking in a linear fashion to branching their arrangement is a major step in thinking. The "Y" formation of the arrangement should be prompted by knowing some patterns are the same age.



Even though we want them to arrange their pattern bottom-to-top, give a group credit for having either a right-side-up or upside-down "Y" shape. They may have been looking either forward or backward in time when they started their arrangement at the bottom.

The most correct pattern arrangement is to the right. The one pattern below does not readily fit into the arrangement.

HANDOUT

A MILLION PENNIES

During recent times, many people are claiming to be a millionaire. People then say, “One million must not be much if so many people have that kind of money!” Perhaps if we can see it in some way, one million of anything may still surprise us.

Let us use money, in this case the lowly penny. Suppose you had a few truck loads of pennies on hand. You place one of those pennies on the ground (outside). Now you decided that on your birthday you would put one penny on top of the penny that is on the ground. You will keep stacking another penny on top, each and every birthday that follows, one penny per year. Imagine how slow that stack of pennies would grow, only one inch high in sixteen years!

How tall would the stack of pennies be now …. If you could jump back in time and start stacking pennies when the following events occurred?

Event: **How** tall is that stack of pennies now?:

Mt. St. Helens Exploded ……..two inches

The United States is formed ……13.6 inches

Columbus First Sailed to America ……..31.25 inches

Christianity Began ……....10 feet high

Pyramids Build in Egypt ……...23 feet high

Mt. Mazama (Crater Lake) Explodes …….40 feet high

The Last Ice Age, (Last Wooly-
Mammoths and Saber-toothed cats)……...52 feet high

First Humans Invade the Pacific
Northwest Area From Asia ……...104 feet high

ONE MILLION YEARS AGO…….5,208 feet high (Almost 1 Mile)

ACTIVITY

POST-EM BELL CURVE

Using Post-it notes, a ruler, and everyone in the class, this activity will allow you to do a population study and graph by measuring one characteristic – height.

Directions: Give each student in the class one sticky post-it note . Each of the students should have their height measured in inches, perhaps against a doorframe. Have the student write their own height, in inches (rounded up to the nearest whole number), upon their post-em note.

As students are being measured, have someone draw a straight, horizontal line 50" long near the bottom of a blackboard. Measure and place a mark every 2" from one end to the other on the line. Under each mark, from left to right, put the numbers 48 through 78. These numbers represent height in inches (the inches convert to 4.5 feet at the left end of the line, and 6.5 feet at the right end).

Have each student place their post-em note on graph line, centered over the inches that match their height in inches. The notes may be stacked, one on top of the other, but not over-lapped. The bottom-most note should touch the horizontal line.

Observe: Connect each of the top-most notes with a line. That line will probably be jagged, but imagine it smoothed out. Would the smoother line be similar in shape to a bell curve, with the highest point near the middle rather than the ends?

Discuss: What does the shape of your curve suggest as to what is the normal, or average height, of someone in your class?

If everyone grows the same amount (let's say 2 inches) over the next two years, which way will your curve move on the graph?

Generally a class will have students of approximately the same age. What if you were to mix two classes that are several grades apart (say 5^{th} and 12^{th} grades) and then post the notes. What might your line connecting the top-most notes look like? (sort of like a curvy "M" … If you can get such measurements, try posting it on a graph.)

What if you had a curve with two prominent peaks, and a big valley between, and all the students were the same age. Discuss what factors/reasons could cause that valley, or void, between the two peaks?

ACTIVITY

CONSTRUCT A TIME-LINE

You Need: 40 feet of masking tape, clear tape, 2-3 feet of bright string, scissors, magic markers, a hallway or gym floor.
Directions: Lay down 35 feet of masking tape onto the floor. (It is okay to go around corners or curve the tape) Be careful not to press it down too hard as you want to easily lift it back up when you are done. Choose one end of the tape to be "the present" and place a dark mark on the tape. Measuring carefully from "the present" mark, draw another mark 10 centimeters from it on the tape and write the number on (1) next to it. Draw another mark 10 cm further, and place the number two (2) next to it. Draw another mark 10 cm further and place the number three, etc., until you complete 100 marks.

The distance between each mark represents one million years! Each centimeter is 10,000 years, and each millimeter is 1,000 years.

By making labels with the tape, or using cutout pictures or drawings, place the following events on your time-line in the appropriate location based upon its age. You can use the string to connect the location on the time-line to the label/cutout, in case an area gets crowded.

Event & Age:

Dinosaur Extinction – 65,000,000 years ago
Age of Mammals Begins – 60,000,000 years ago
Earliest Human-like Primates – 4,000,000 years ago
Earliest human Culture – 2,000,000 years ago
Christianity Began – 2,000 years ago
Goose rock material was deposited – 100,000,000 years ago
Ice Age ends – 10, 000 years ago
First Grasses evolved – 40,000,000 years ago
Ancestral Cascade Mountains start to form – 40,000,000 years ago
Modern Cascade Mountains start to form – 5,000,000 years ago
First Glacial Period of the Ices Ages – 2,000,000 years ago
Mt. Mazama (Crater Lake) explodes – 7,700 years ago
Beginning of the Clarno Formation – 50, 000,000 years ago
Beginning of the John Day Formation – 39,000,000 years ago
Beginning of the Picture Gorge Basalts – 16,000,000 years ago
Beginning of the Mascall Formation – 15,000,000 years ago
Beginning of the Rattlesnake Formation – 8,000,000 years ago